NITROGEN, ARGON AND XENON IN HAPPY CANYON E CHONDRITE.

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Introduction: An interesting aspect of enstatite chondrites (EC) lies in their oxygen isotopic compositions that are identical to those of the Earth-Moon system [1]. Thus it has been suggested that Earth could have accreted mostly from EC [e.g., 2]. Similarly, based on an assessment of nitrogen and oxygen isotopes in martian meteorites about 75 % contribution from EC type materials to the accretion of Mars has been proposed recently [3]. The suggestion that EC type materials could have played a key role in the accretion of earth-like planets is also consistent with the bulk chemical compositions of these planets [e.g., 4]. Earlier nitrogen studies [e.g., 5] have shown that EC have a number of isotopic components in them, which are poorly understood, and so are the hosts of these components. In this context, it is useful to study nitrogen combined with another tracer. Carbon has been used (e.g., [5]), but another approach could be one using noble gases, which have been shown to be useful tracers for solar system studies [e.g., 6]. However, simultaneous nitrogen and noble gas data on EC are scarce so far. Here we report on the analysis of a 0.68 mg sample of Happy Canyon (EL6) simultaneously for its nitrogen and noble gas isotopic compositions, as part of an ongoing study of EC.

Experimental: Gas extraction was carried out from the sample wrapped in Pt foil by stepped pyrolysis in an Ir crucible. The experimental procedure adopted for the present study was similar to those of [7]. Sensitivities for nitrogen, argon and xenon were 0.36 pg/mv (analogue mode), 2×10^{-15} ccSTP/cps and 9×10^{-16} ccSTP/cps (ion counting mode), respectively. Typical high temperature (1600 ^{o}C) blanks were 80 pg for nitrogen, 3.8×10^{-12} ccSTP for ^{36}Ar and 1.3×10^{-14} ccSTP for ^{132}Xe. Data presented here have been corrected for procedural blanks and instrumental mass discrimination. The nitrogen data have additionally been corrected for contributions from CO.

Although our experimental procedure allows the analysis of all the noble gases along with nitrogen in the same experiment, because of the small sample size and ambient blanks for the light noble gases no useful data for He and Ne could be obtained. With a slightly modified procedure for the heavy noble gases (because of the low Kr and Xe amounts, Kr and Xe were measured in the same fraction - Kr after Xe), we could obtain useful isotopic data for argon and to some extent for xenon, however.

Results: The stepped temperature release of nitrogen is shown in Fig. 1. The low temperature step (500 ^{o}C), which was intended to remove terrestrial contamination, may also have removed some low temperature indigenous nitrogen, as reflected in its heavy δ^{15}N. This step accounts for only 4 % of the sample gas with a δ^{15}N of +34 ‰. Nitrogen released in the subsequent steps are much lighter in δ^{15}N, reaching –32 ‰ in the 1200 and 1600 ^{o}C steps (which account for ~80 % of the sample nitrogen). Nitrogen in the 900 ^{o}C step can be explained by a mixture of two components with δ^{15}N of +34 and –34 ‰ released at the low and high temperatures respectively. The true δ^{15}N of the low temperature component may be much heavier than that observed at 500 ^{o}C because of the following reasons. It is expected to have a contribution from terrestrial contamination and might be influenced by the dominating (80 % of sample gas) light nitrogen component, both of which would make it lighter. The low temperature release of the heavier component suggests it to be from organic materials, but it could also be from other low temperature phases. The lighter component released at the high (>1200 ^{o}C) temperatures, similar to that observed in other enstatite chondrites (e.g., [5]) and achondrites (e.g., [8], is hosted probably by enstatite or other high temperature phases.

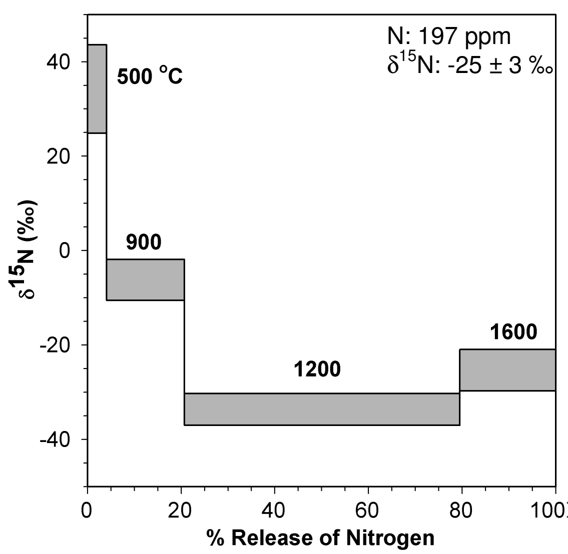

Fig. 1. Stepped temperature release of nitrogen.

It is interesting to note that nitrogen with an isotopic composition as light as –25 ‰ has been observed in mantle-derived materials from Earth [9, 10]. Similarly, nitrogen isotopic data from martian meteorites indicate that nitrogen in the martian mantle could be as light as –30 ‰ [3, 11]. As discussed in [2–3], these light nitrogen signatures are suggestive of significant EC contributions to the accretions of Earth and Mars, which have been shown to be consistent with their bulk chemical compositions [e.g., 2–4].

Fig. 2 depicts the step temperature release of ^{36}Ar and the ^{40}Ar/^{36}Ar ratio, both after correction for cosmogenic contributions (assuming a solar like trapped ^{36}Ar/^{38}Ar of 5.5 ± 0.2, [12]). The low ^{40}Ar/^{36}Ar in the 500 °C step can be explained as a mixture of terrestrial contamination and contribution from sample gas. The ^{40}Ar/^{36}Ar ratio of ~2400 observed in the 900 °C step indicates contribution from a radiogenic component, the contribution of which decreases in the subsequent higher temperature steps. The present step temperature data suggest a trapped ^{40}Ar/^{36}Ar < 140 for Happy Canyon. The ^{36}Ar/^{14}N atomic ratio of 1×10^{-7} measured in the present sample (~3×10^{-7} in EC, [13]) is similar to that measured for the Earth's mantle (~2×10^{-7}, [e.g., 14]).

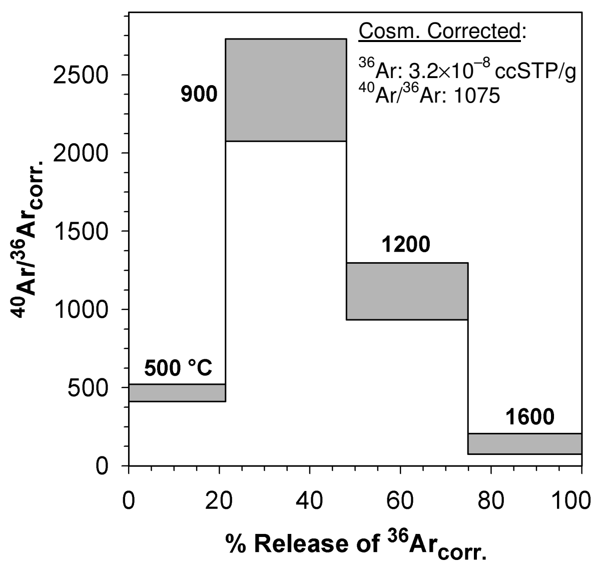

Fig. 2. Stepped temperature release of cosmogenic corrected argon.

Xenon measured in the present sample has a concentration (^{132}Xe) of 1.8×10^{-10} ccSTP/g and a ^{129}Xe/^{132}Xe ratio of 3.4. Fig. 3 shows the stepped temperature release in the present experiment. ^{129}Xe/^{132}Xe in the low temperature (500 and 900 °C) steps and the 1600 °C release are indistinguishable from the air or solar signatures. But a ^{129}Xe/^{132}Xe ratio of ~8.4 observed in the 1200 °C step, which accounts for ~30 % of sample ^{132}Xe, clearly stands out and shows the presence of ^{129}I-decay xenon.

Although the concentrations and isotopic compositions of nitrogen and noble gases measured in the present sample fall in the ranges observed in other enstatite chondrites, the present sample has higher measured ^{36}Ar (3.4×10^{-8} ccSTP/g) concentration than the earlier measurements of Happy Canyon [15–16]. Similarly, the present measured ^{38}Ar/^{36}Ar (0.276), ^{40}Ar/^{36}Ar (1000), ^{132}Xe and ^{129}Xe/^{132}Xe are lower than those of the earlier studies. The simultaneous release of light nitrogen and radiogenic ^{129}Xe at 1200 °C suggests a common host phase. This is interesting in light of an earlier suggestion that ^{129}Xe in this meteorite probably resides in micro bubbles [17]. In that case, these bubbles must be able to retain their gases (N and Xe) beyond 900 °C. Whatever this phase, it is probably different from that (K-rich phase) from which the radiogenic ^{40}Ar is released at 900 °C.

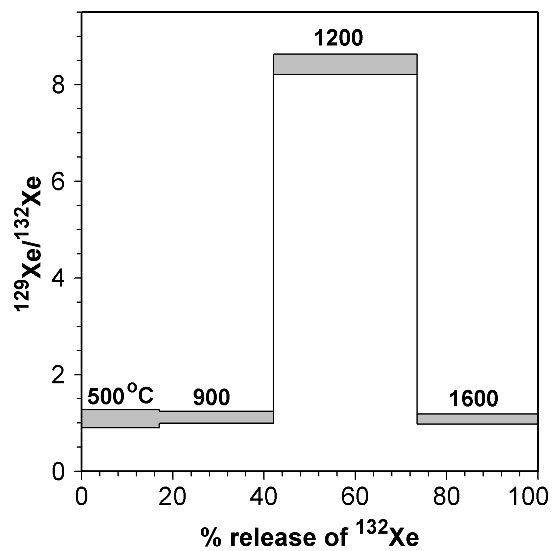

Fig. 3. Stepped temperature release of xenon.

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References: [1] Clayton R. N. (1993) *Ann. Rev. Earth Planet. Sci., 21*, 115–149. [2] Javoy M. (1995) *GRL, 22*, 2219–2222. [3] Mohapatra R. K. and Murty S. V. S. (2003) *MAPS, in press*. [4] Wänke H. and Dreibus G. (1988) *Philos. Trans. R. Soc. Lond., A 325*, 545–557. [5] Grady M. et al. *GCA, 50*, 2799–2813. [6] Ozima M. and Podosek F. (2002) Cambridge Univ. Press. [7] Mohapatra R. K. et al. (2001) *MAPS, 36,* A139. [8] Murty S. V. S. and Marti K. (1990) *Meteoritics, 25,* 227–230. [9] Cartigny P. et al. (1997) *Terra Nova,* 9, 175–179. [10] Mohapatra R. K. et al. (2002) *GCA,66,* A517. [11] Mathew K. J. and Marti K. (2001) *JGR, E106,* 1401–1422. [12] Wieler R. (2002) *Rev. Mineral. & Geochem., 47,* 21–70. [13] Pepin R. O. (1991) *Icarus, 92,* 2–79. [14] Marty B. (1995) *Nature, 377,* 326–329. [15] Crabb J. and Anders E. (1981) *GCA, 45,* 2443–2464. [16] Patzer A. and Schultz L. (2001) *MAPS, 36,* 947–961. [17] Takaoka N. et al. (1996) *LPS, 27,* 1303-1304.